Heat Sink Welding for Preventing Hot Cracking in Alloy 2195 Intersection Welds: A Feasibility Study

Yu-Ping Yang and Pingsha Dong
Center for Welded Structure Research
Battelle Memorial Institute

Patrick Rogers
NASA
Marshall Space Flight Center

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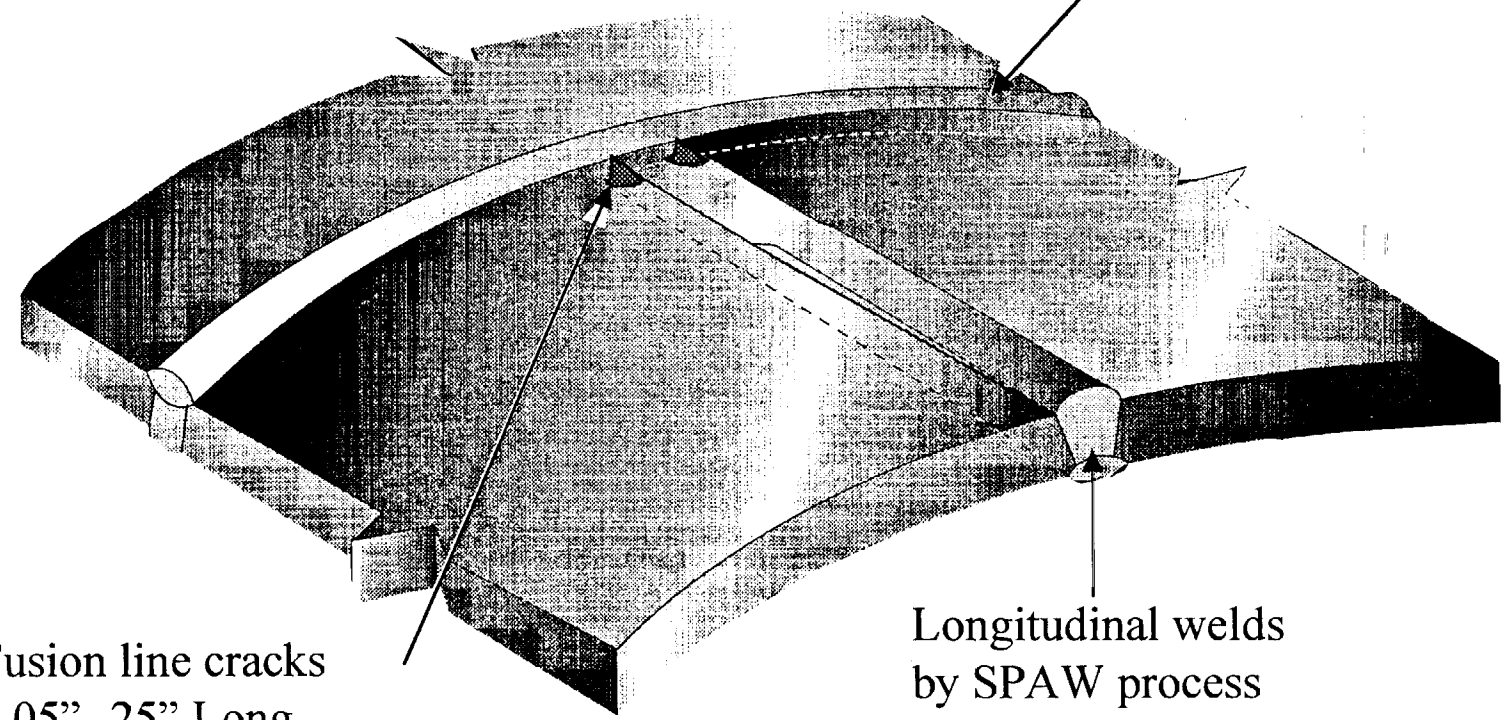
Potential Weld Crack Sites of Concern



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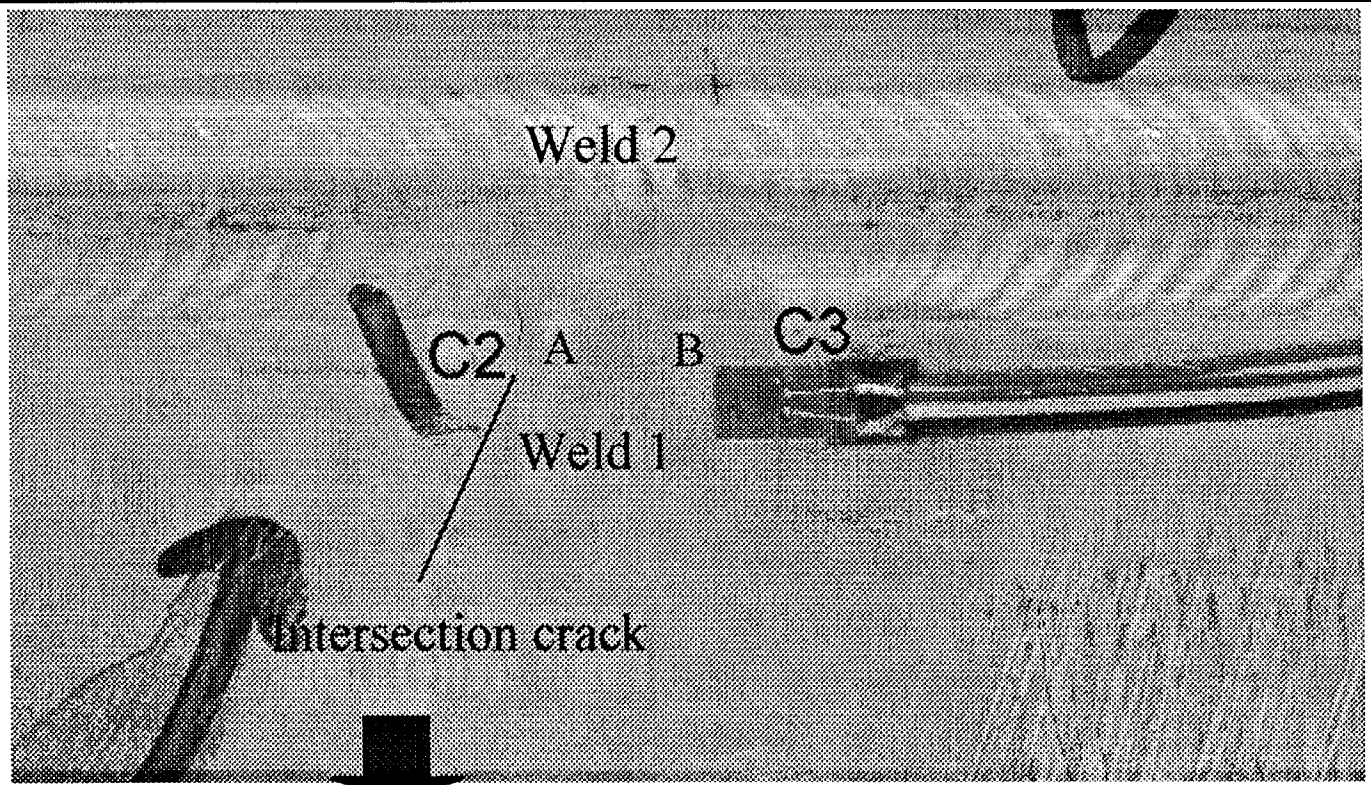
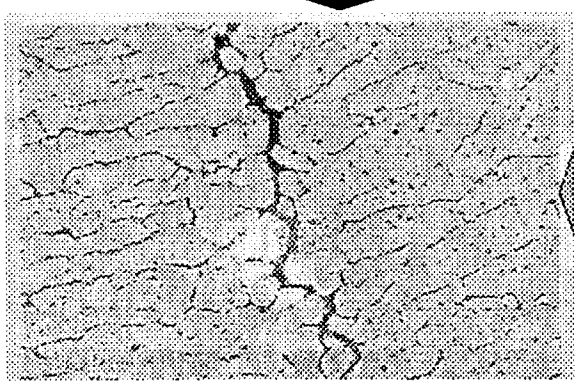
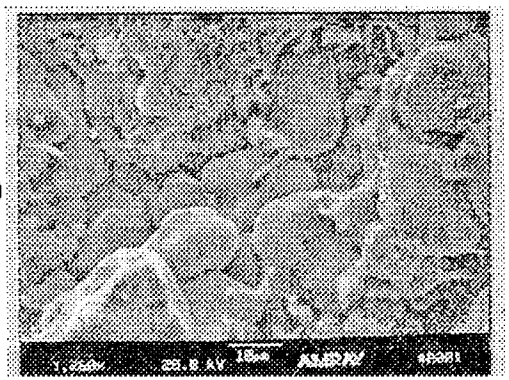
Intersection Crack - A Test Panel Weld







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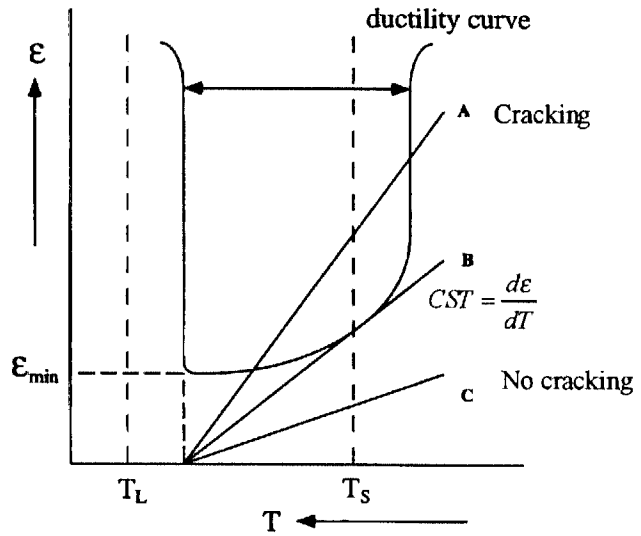
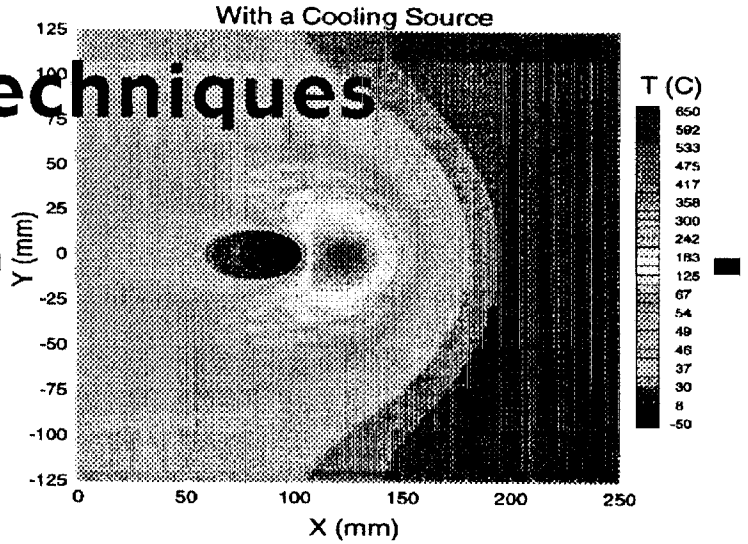
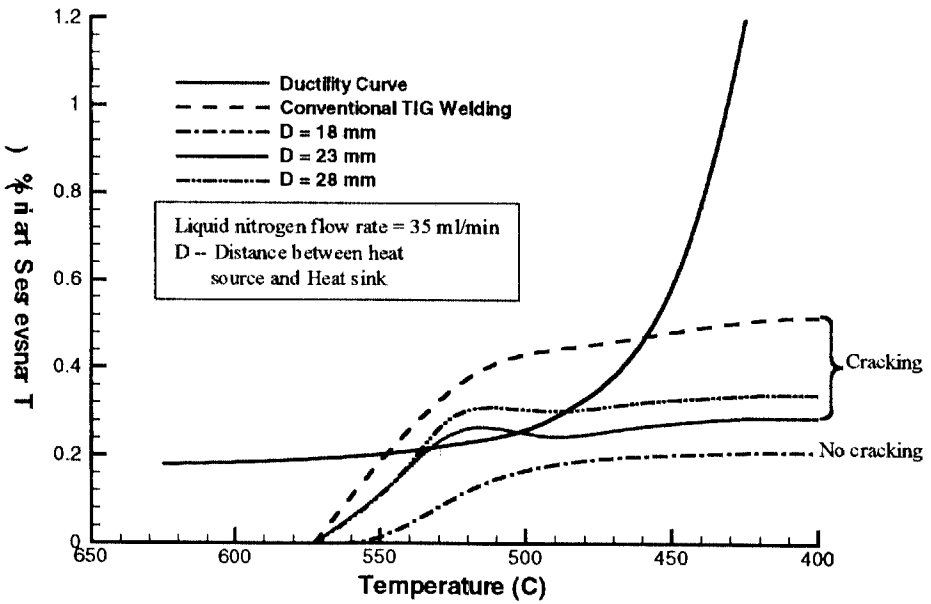
Hot-Cracking Mitigation Techniques with a Heat Sink



(a) Thermomechanical Conditions Associated with Hot Cracking

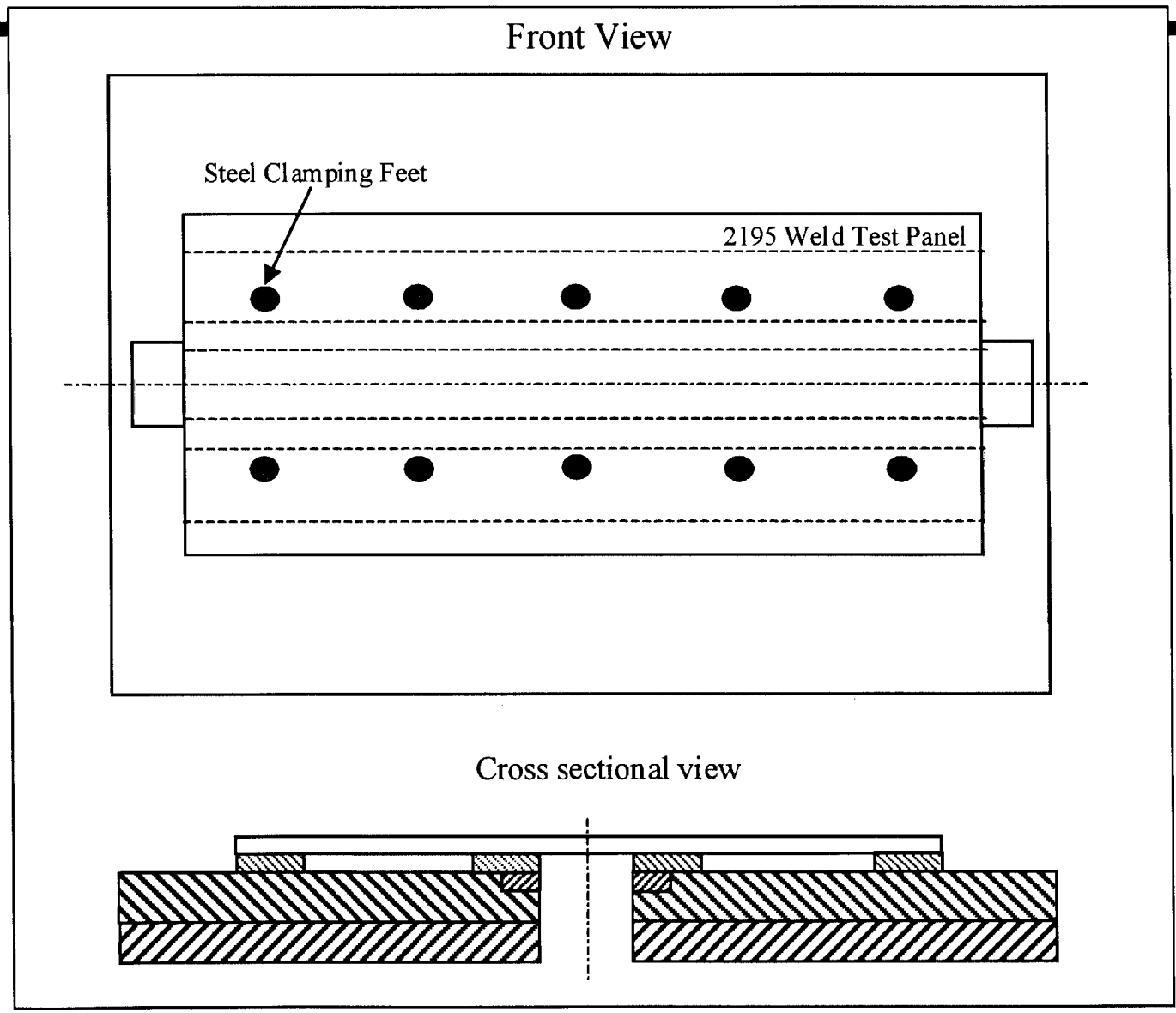


(b) Temperature Distribution welding with a Heat Sink



(c) Effects of Heat Sink on Development of Tensile Strain

Weld Test Panel and Fixture for thermocouple panels



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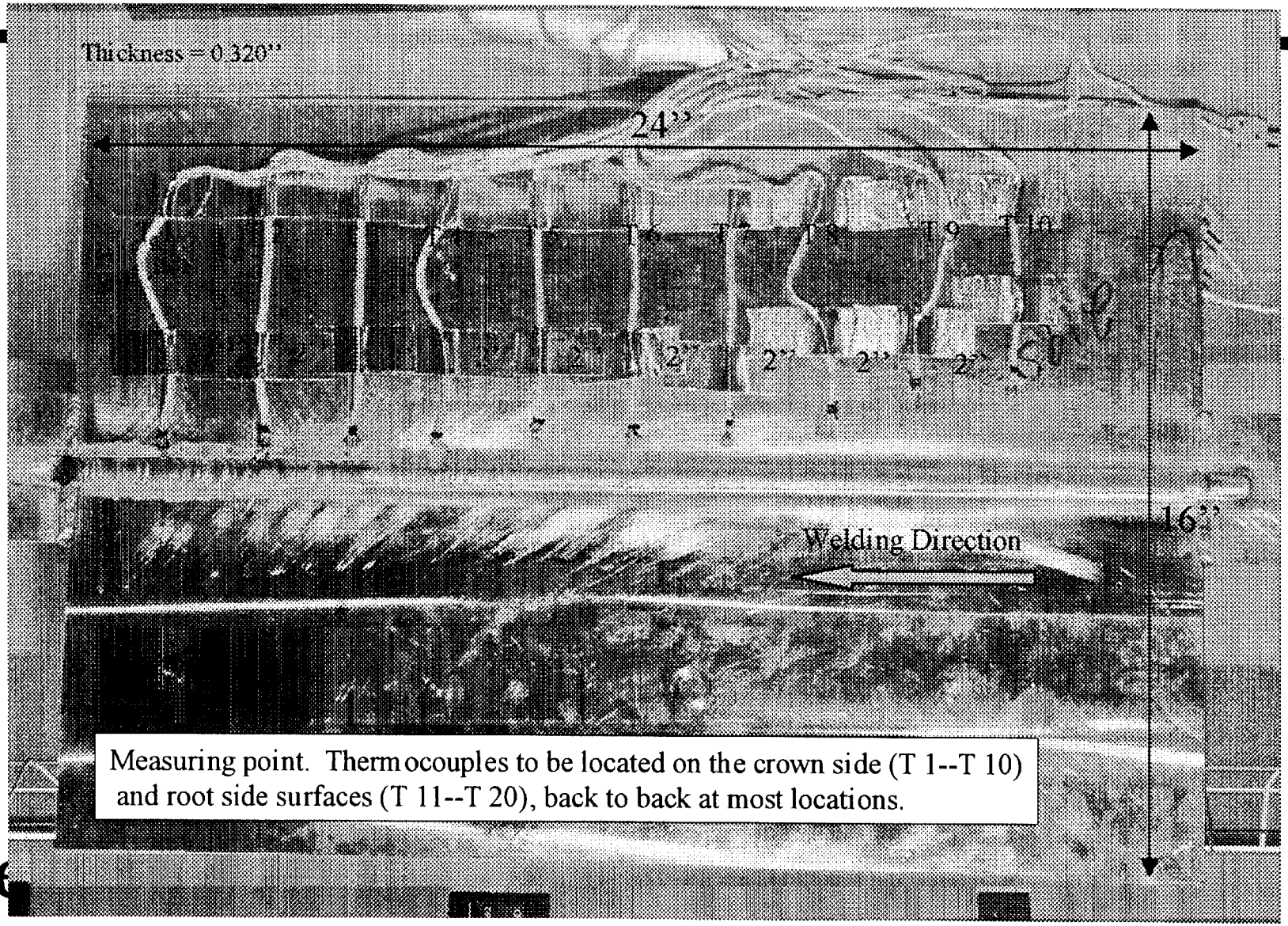
Thermocouple Locations on a Test Panel



Measuring point. Thermocouples to be located on the crown side (T 1--T 10) and root side surfaces (T 11--T 20), back to back at most locations.

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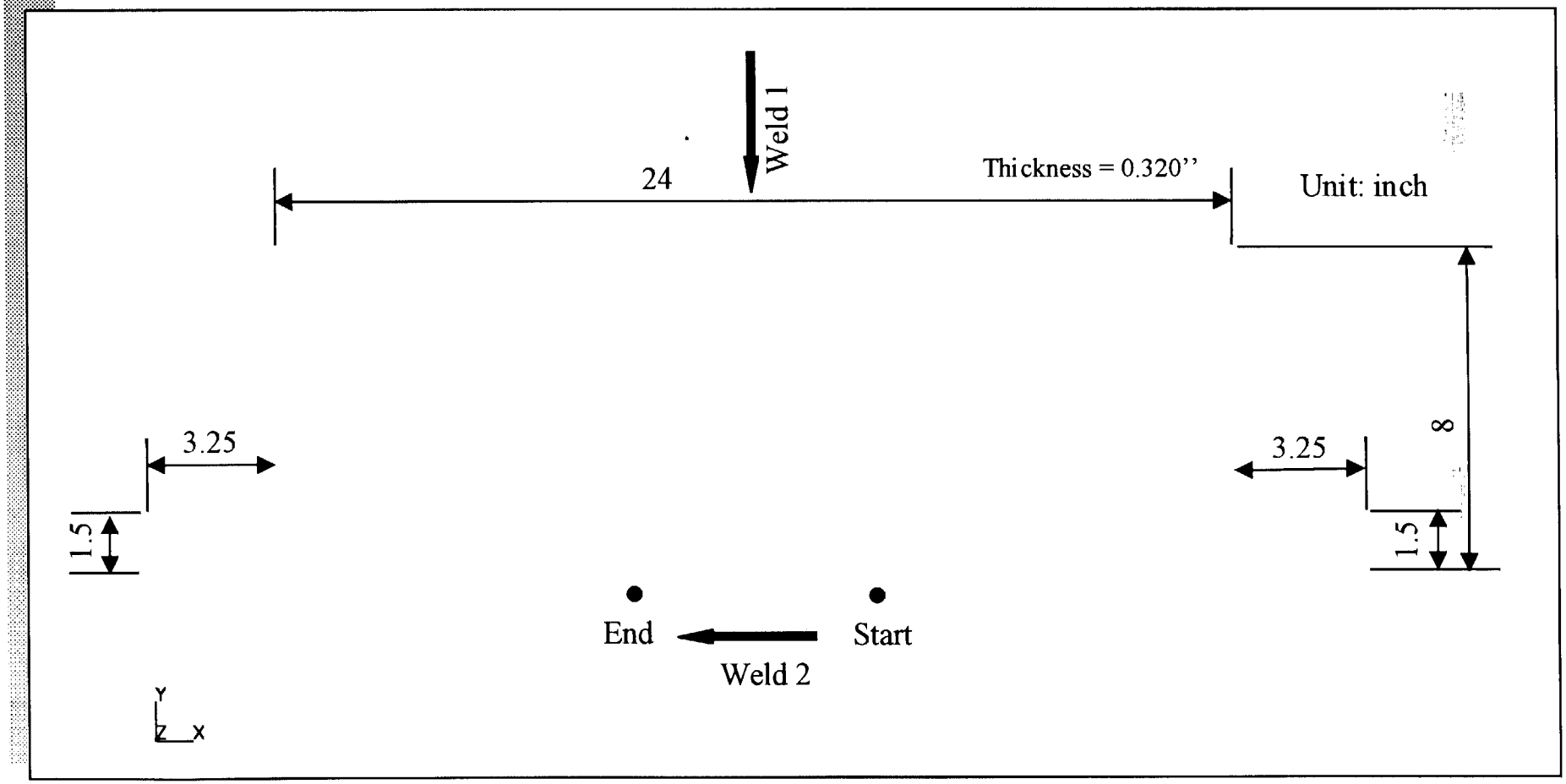
Finite Element Model (8-node element)



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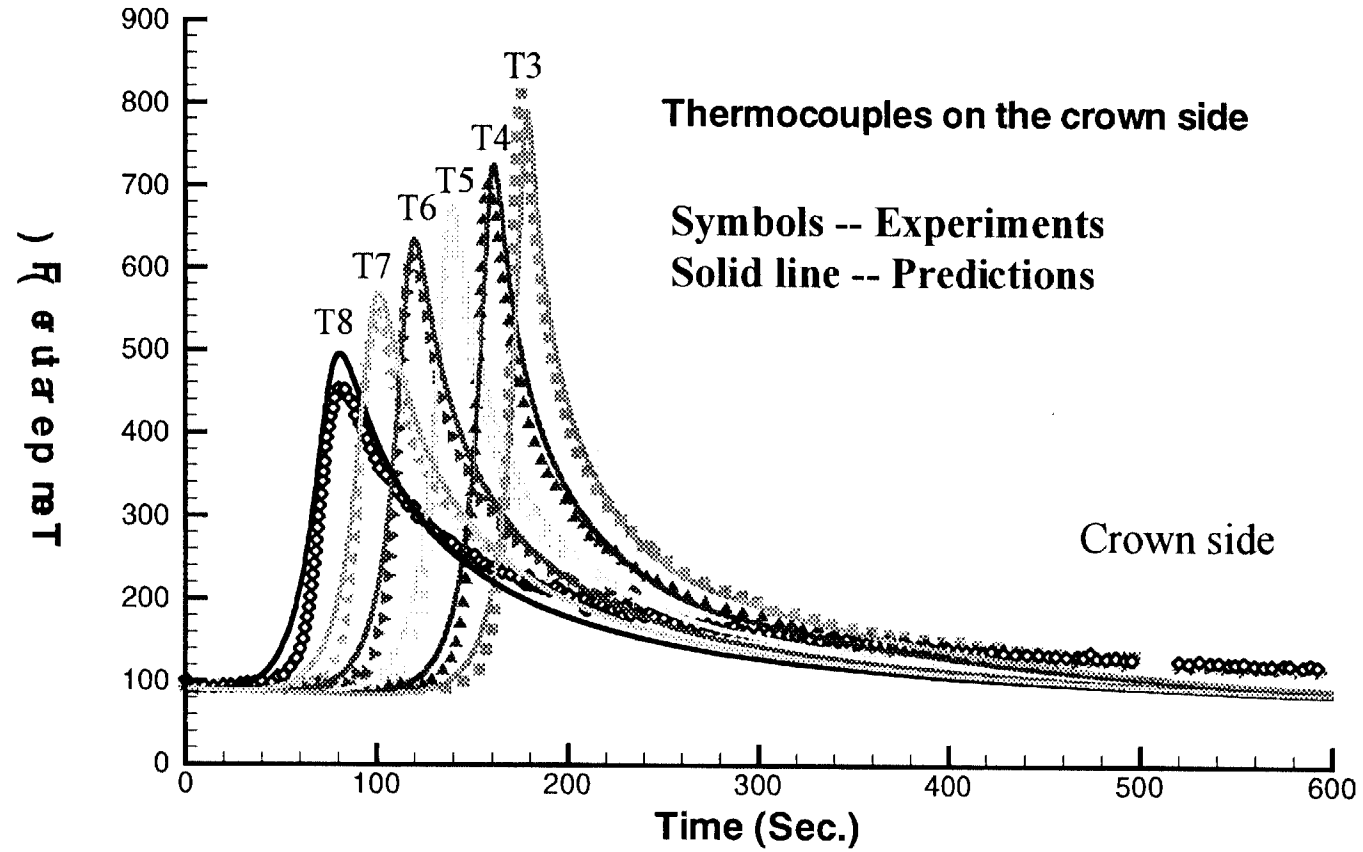
Comparison of Temperature Histories between Experiment and Prediction



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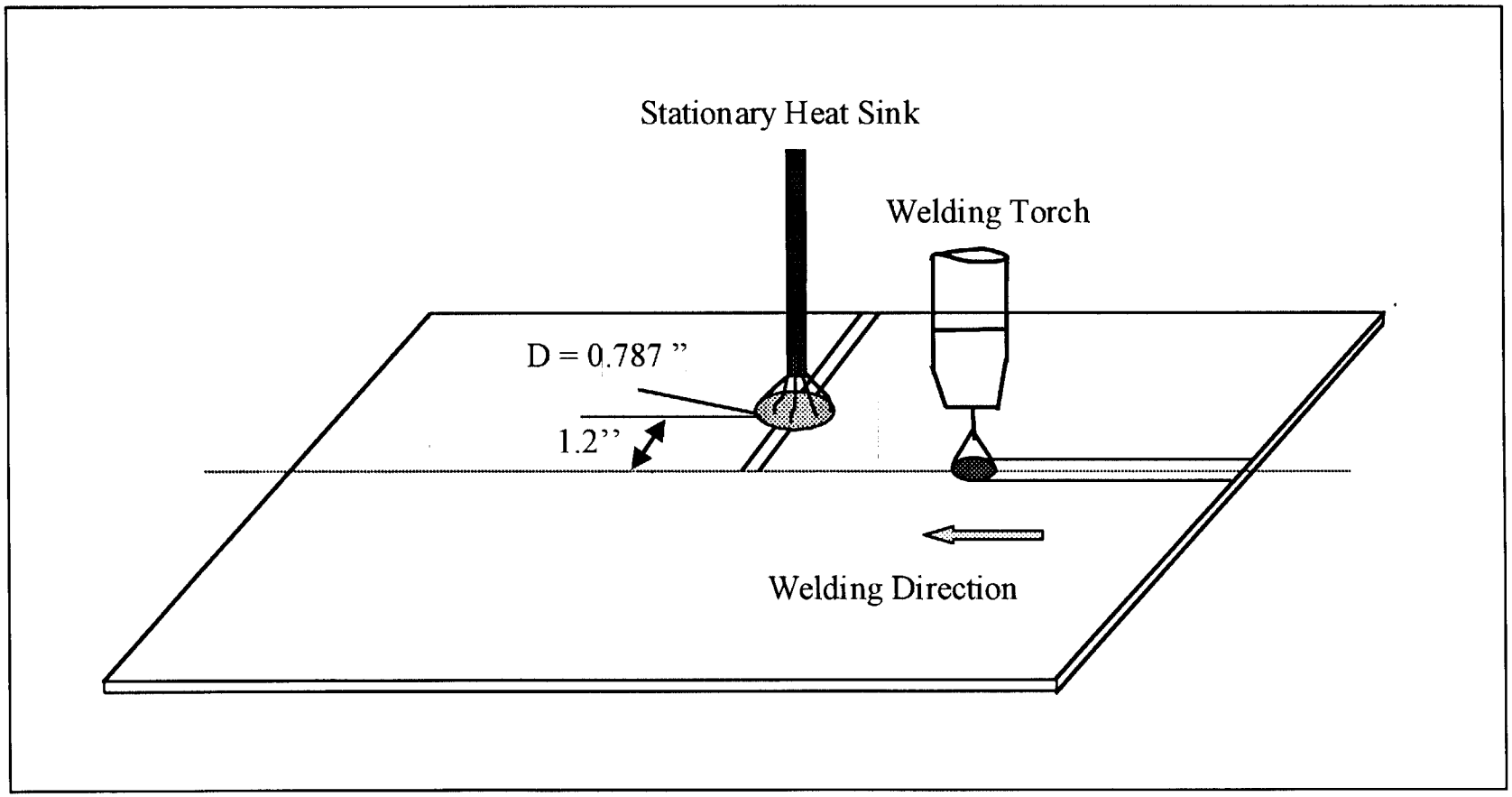
Proposed Stationary Cooling Technique



Cooling media option:

- Liquid nitrogen
- Water
- Pressurized air knife

Cooling device option:

- Heat pipe
- Heat pipe with bronze brush

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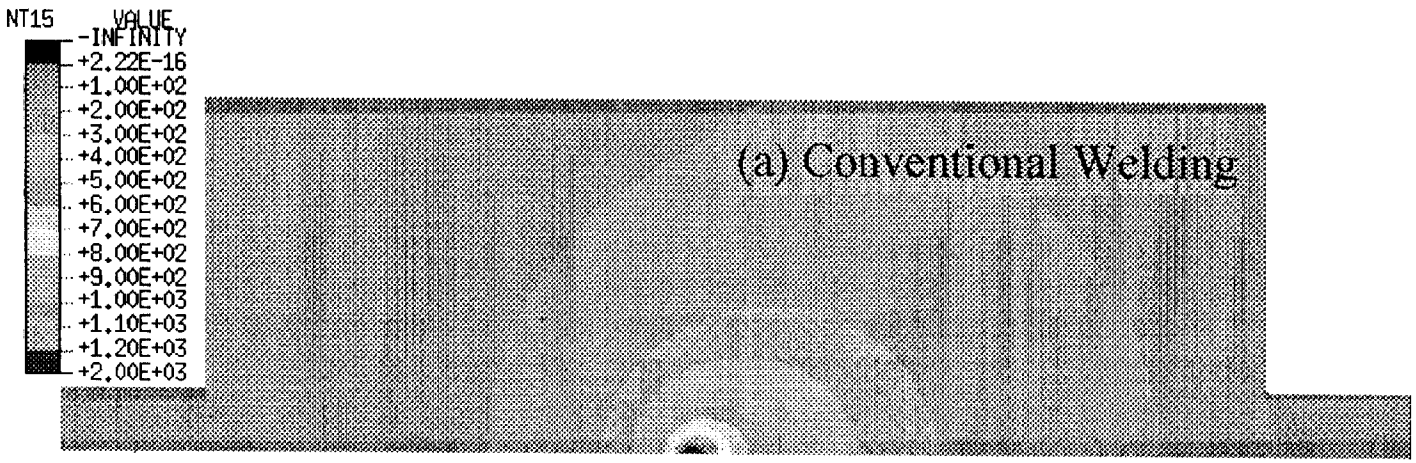
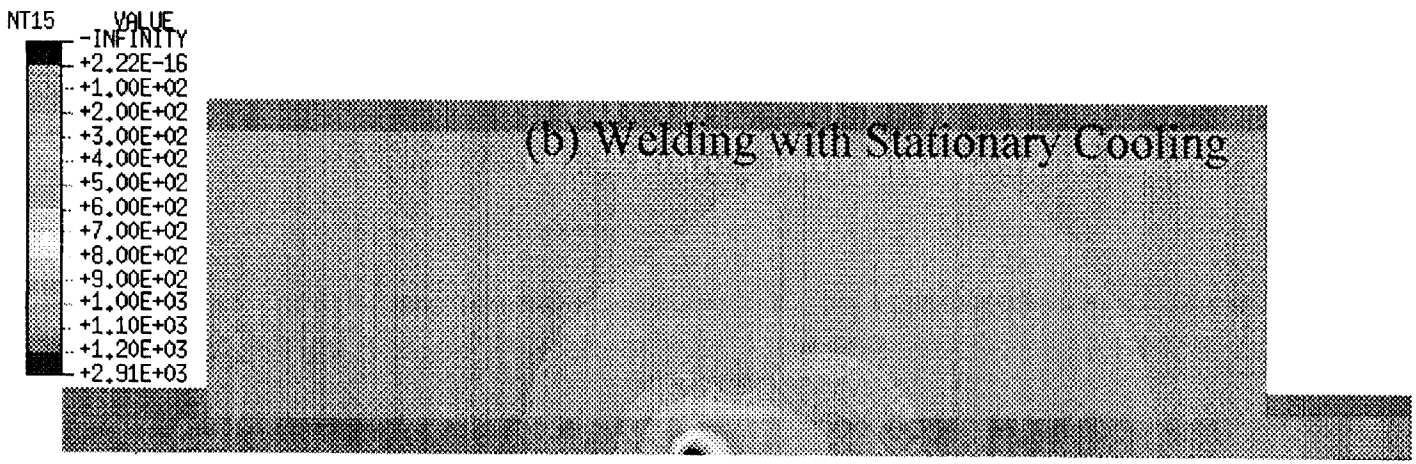
Temperature Comparison Between Conventional Welding and Welding With Stationary Cooling



(a) Conventional Welding



(b) Welding with Stationary Cooling

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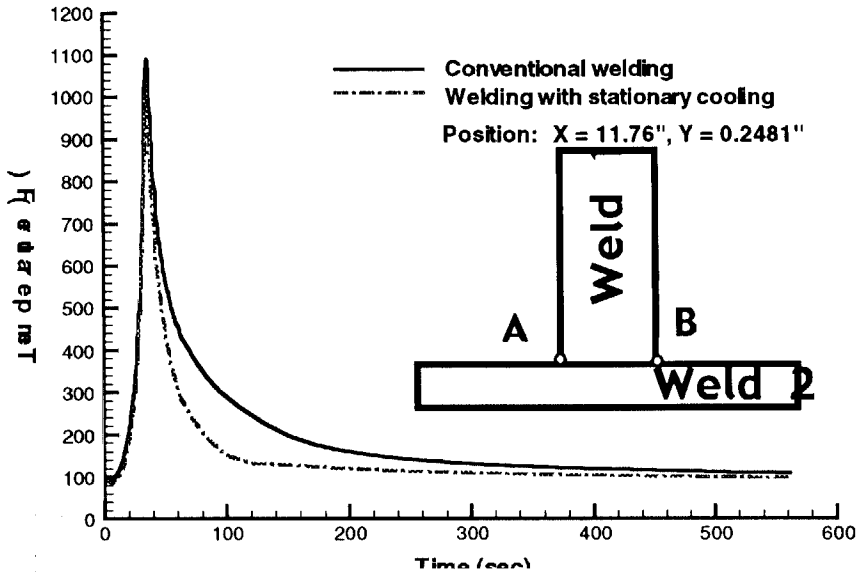
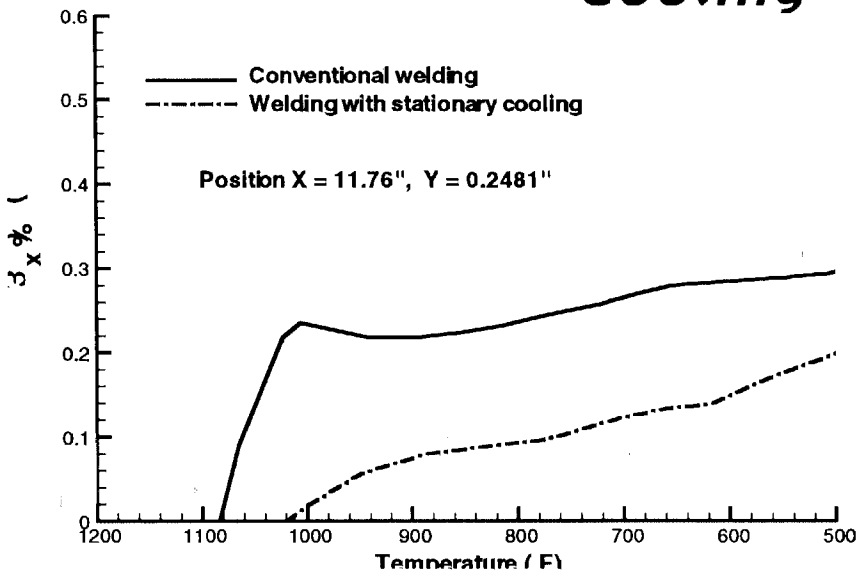
Temperature and Longitudinal Tensile Strain of Intersection during Welding

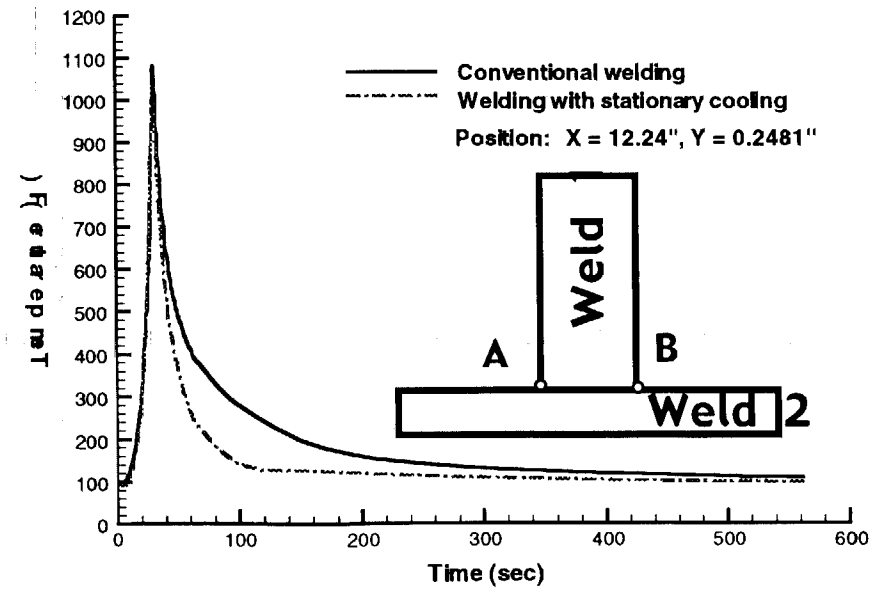
Stationary Cooling

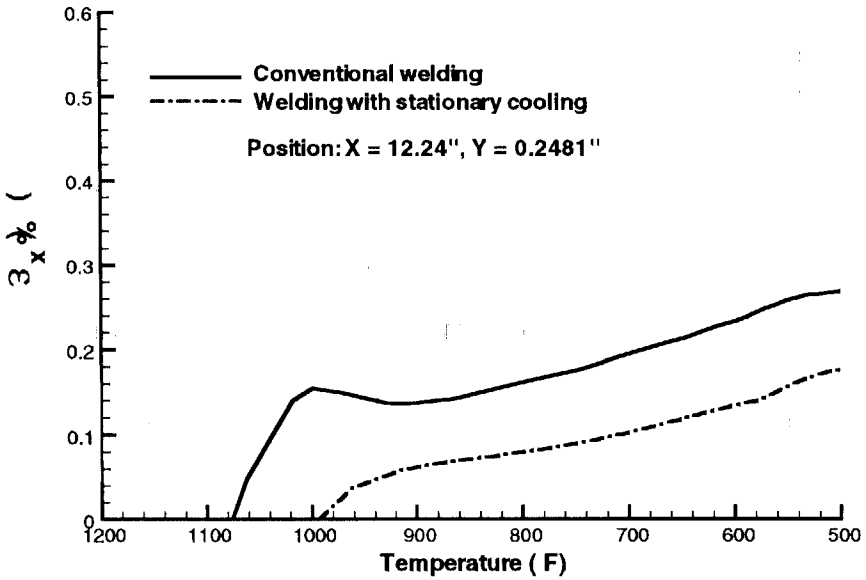
(Point A)



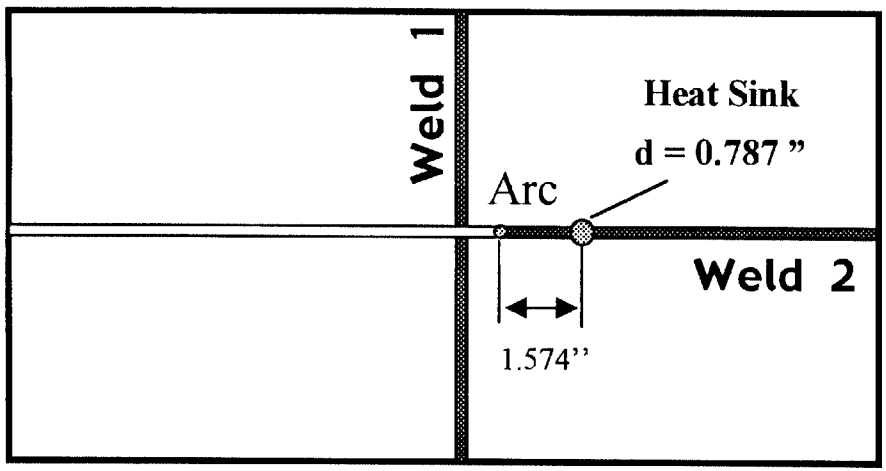


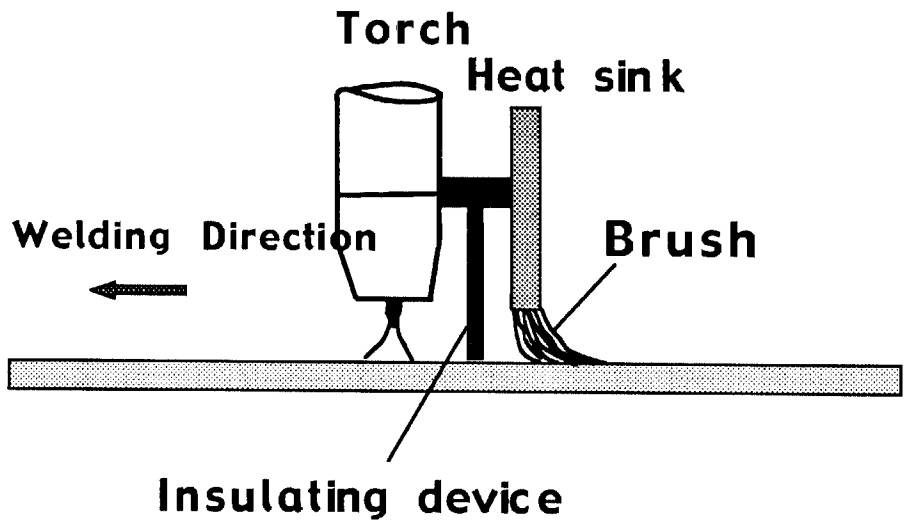
(Point B)





Proposed Trailing Heat Sink Techn





Cooling media option: Liquid nitrogen or Pressurized air knife

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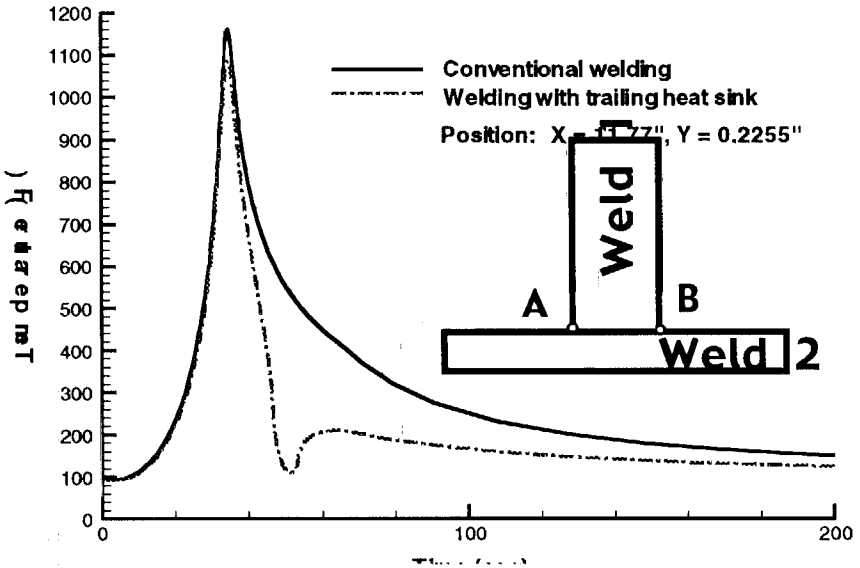
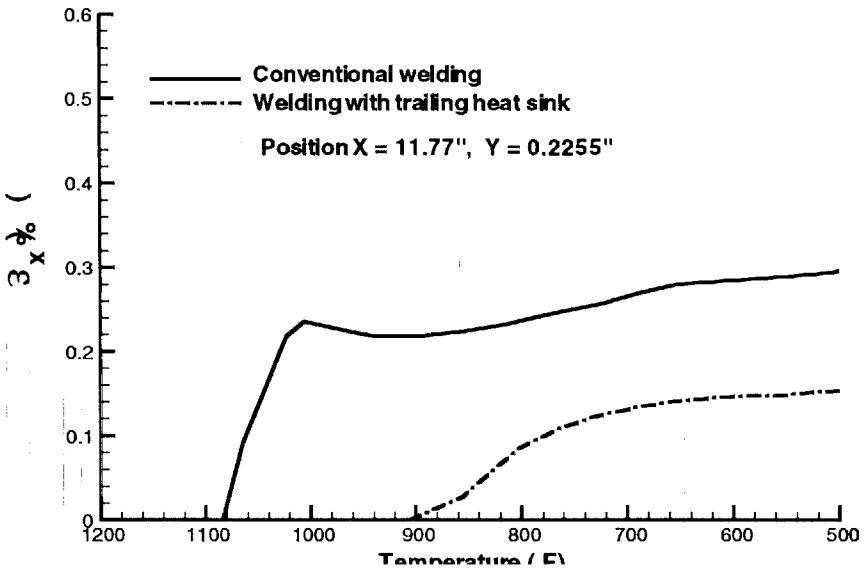
Temperature and Longitudinal Tensile Strain of Intersection during Welding

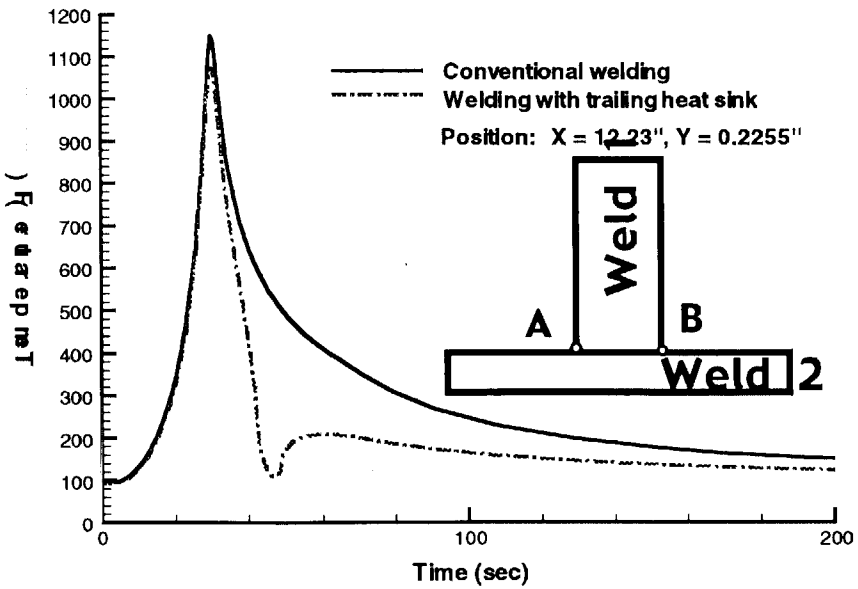
Heat Sink Technique

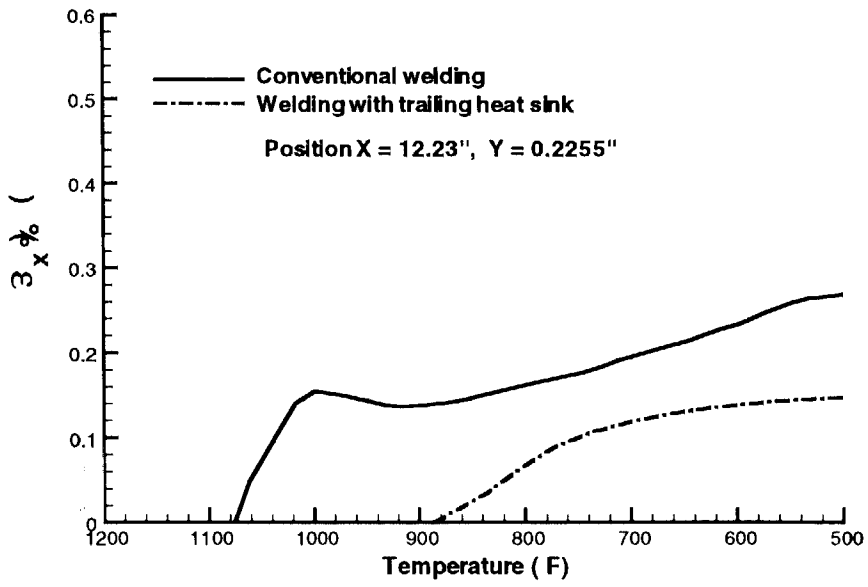
(Point A)



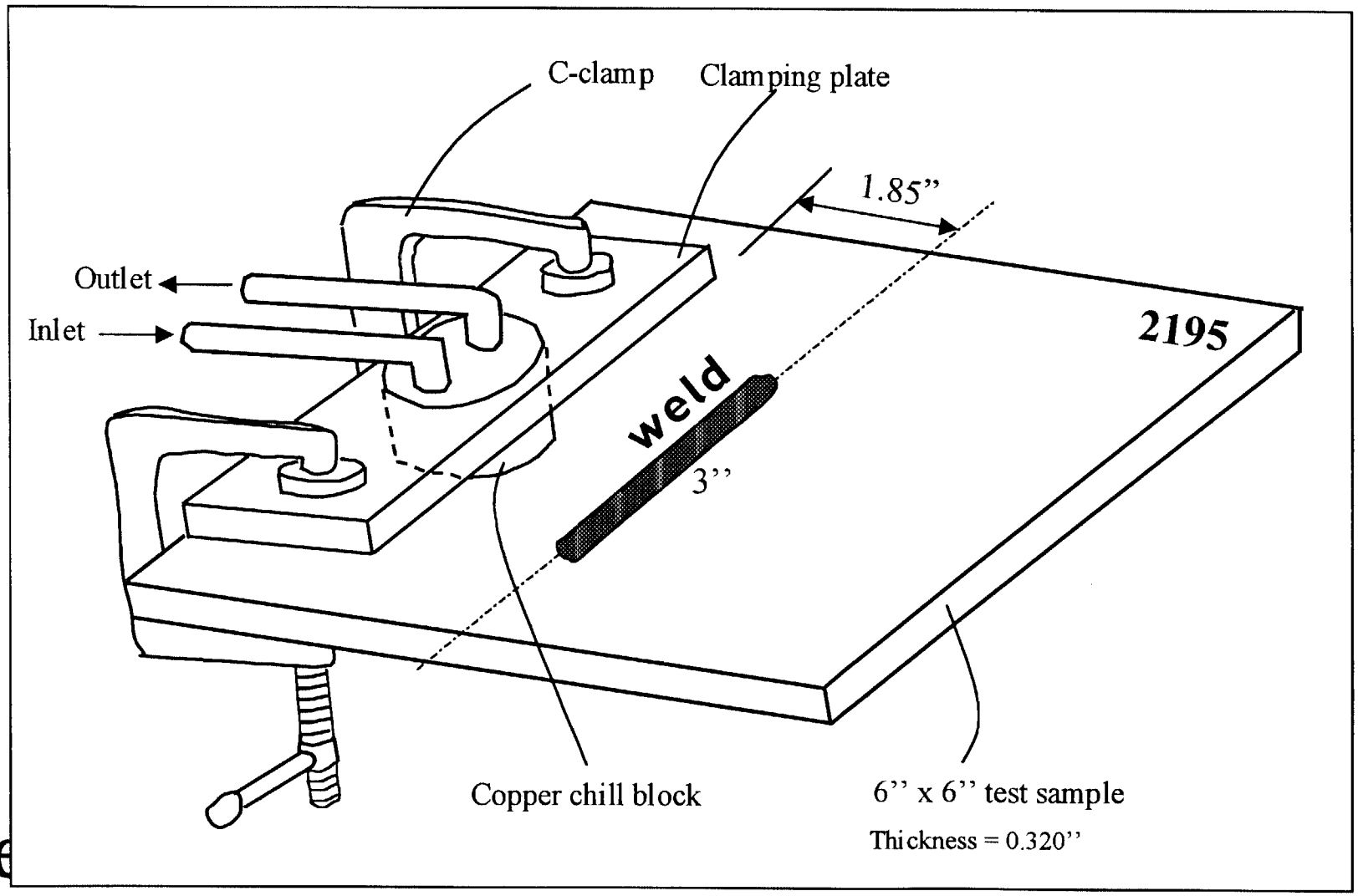


(Point B)

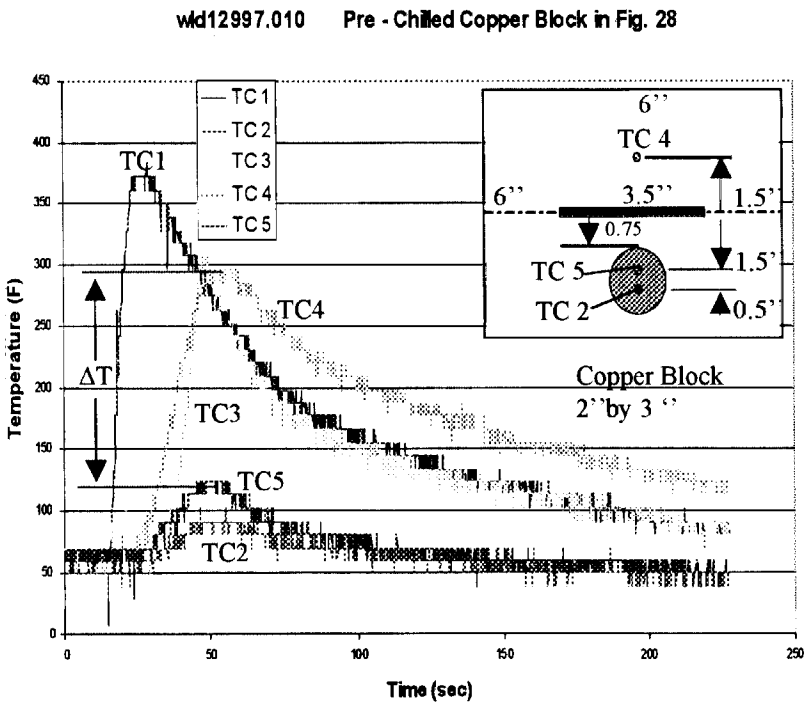




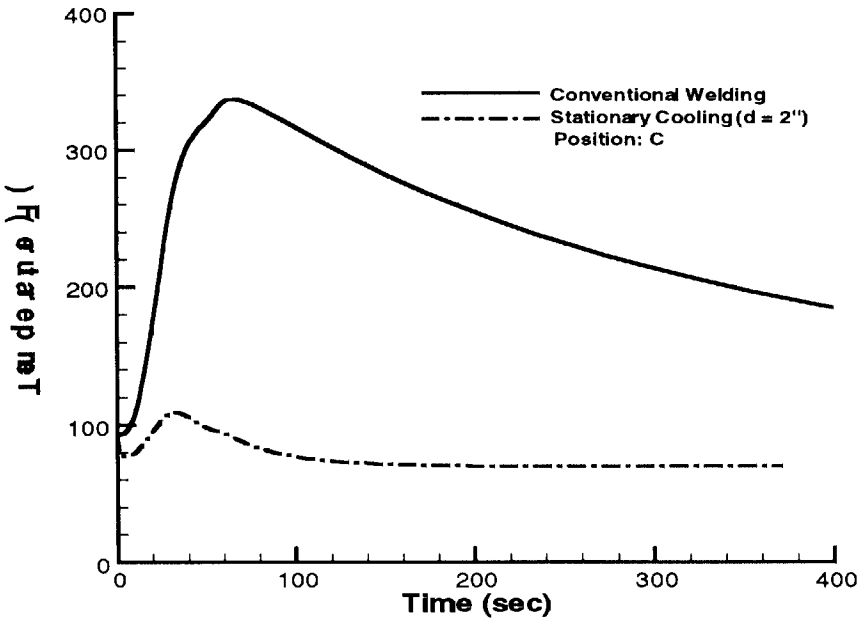
Varestrain Machine Chill Block Test Setup



Temperature Difference (ΔT) induced by Chill Block



(a) Measured Temperature



(a) Predicted Temperature

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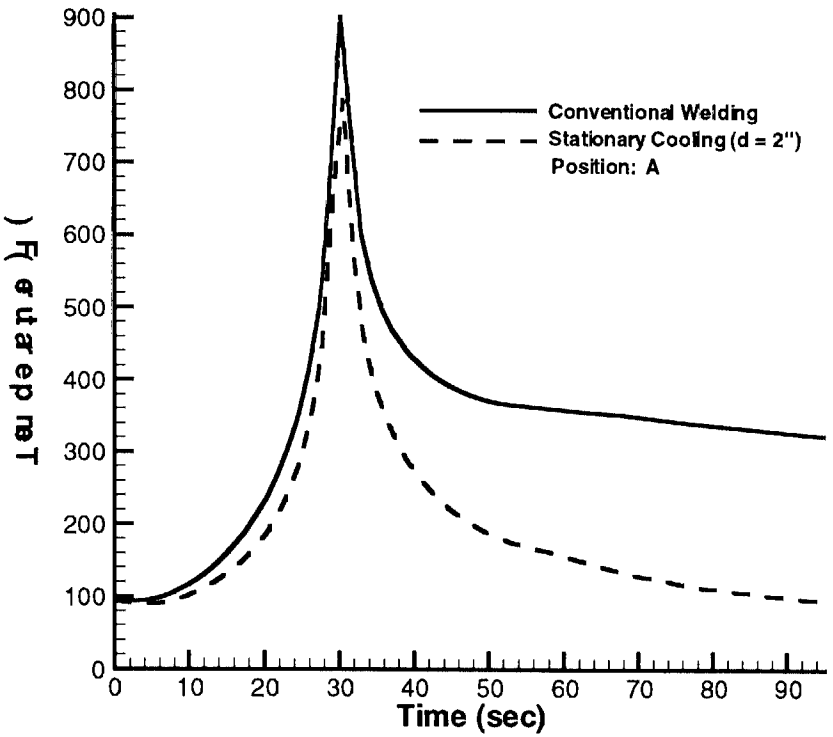
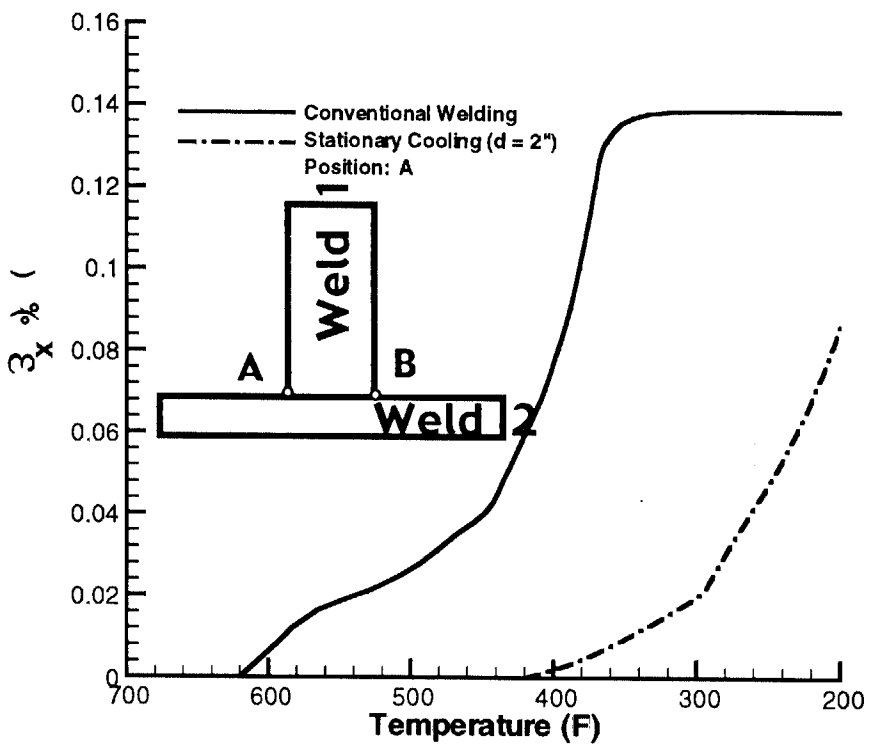
Temperature and Strain History at Point A



(a) Temperature



(b) Longitudinal tensile strai

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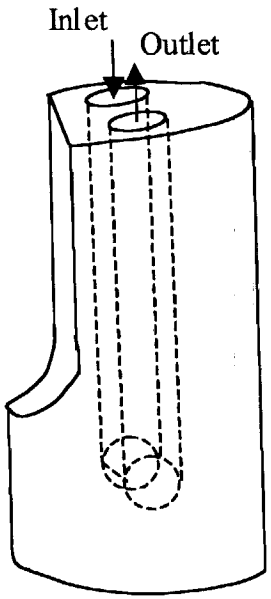
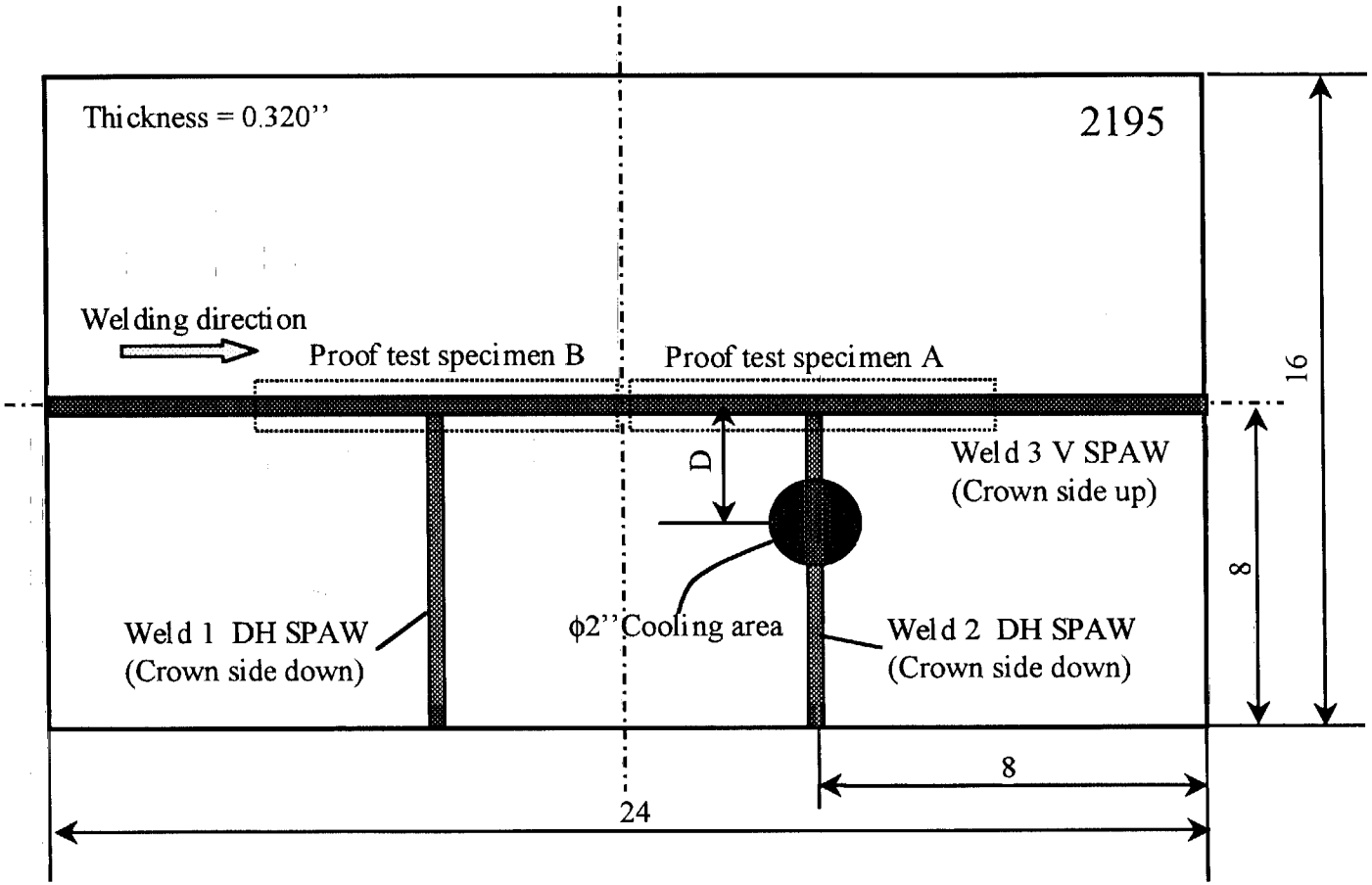
"Quick Look" Intersection Weld Test for Stationary Heat Sinking Evaluation



(a) Chill Block



(b) Weld Sample

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Summary and Future Work

- Two concepts, stationary cooling and trailing cooling, were proposed to prevent weld intersection cracking. Finite element analysis was used to demonstrate the potential effectiveness of those two concepts.
- Both stationary and trailing heat sink setups were proposed for preventing intersection cracking. The cooing media could be liquid nitrogen, or pressured air knife.
- Welding experiments on the small test panel with the localized heat sink confirmed the feasibility of using such a stationary cooling technique. The required cooling was achieved in this test panel.
- Systematic welding experiments should be conducted in the future to validate and refine the heat sink technique for preventing intersection cracking.

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